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# BOARD OF EDITORS

REV. RICHARD B. SCHMITT, S.J.
Editor of the Bulletin
1929-1940

The Reverend President, the Reverend Editors, and the Members of the American Association of Jesuit Scientists wish to express their sincere appreciation and gratitude to

REVEREND RICHARD B. SCHMITT, S.J.

on his retirement from the editorship of the BULLETIN after eleven years of arduous labor and exceptional devotion in a task which involved countless difficulties but which he performed so faithfully and so well.

# SCIENCE and PHILOSOPHY

## THE LIMITATIONS OF PHYSICAL KNOWLEDGE*

ARTHUR E. HAAS, Ph. D.

Isaac Newton, perhaps the greatest scientist of all time, a few months before his death remarked to one of his friends: "I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the sea shore, and diverting himself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."

So said the great Newton about two centuries ago. Although physics has made enormous and undreamed of progress since his death, Newton's wise and humble words still apply today, even to a greater extent than at the time when they were first spoken. In our age physicists began to recognize more and more that nature itself places limitations on physical knowledge.

About twelve years ago the development of a new branch of theoretical physics led to the derivation of a most important principle of atomic physics, now known as the principle of indeterminacy. It is not easy for the non-physicist to understand this principle when it is formulated in exact technical terms. Starting with the fact that perfectly accurate measurements are not possible in physics, we could then make the following half-technical, half-popular statement:

In motion which occurs in the interior of atoms, the product of the inaccuracies in the determinations of the speed and the distance from the center of the atom must be as large as the actual product of that speed and distance. To use a very trivial comparison, the physicist who wants to determine motion within the atoms, is in a position similar to that of a man who would try to control his weight by means of a scale which shows errors of about 150 lbs.

It might be somewhat difficult for the layman to grasp the full meaning of the principle of indeterminacy, but a popular form may easily be given to an important conclusion which necessarily results from this principle. This conclusion is that the single ultimate particles of which matter is composed are something hazy, of indeterminable position, of indeterminable motion, and of indeterminable size and shape.

The conclusion appears unescapable that a single ultimate particle can never be the object of physical consideration, and that it is

*Paper read at the National Science Convention, Chicago, Illinois, Sept. 4th-6th, 1940.

therefore unreasonable to apply the methods of physics and the laws of nature to individual particles. The behavior of a single particle as an individual cannot possibly be described in the language of physics.

Thus the modern scientist finds a limit to his exploration should he be interested in dimensions as small as those of the ultimate particles of which matter is composed. A fact which is not very well known is that, besides this lower limit, the scientist faces also an upper limit to his exploration. He would face this other barrier should he attempt to penetrate distances about five or ten times greater than the largest distances covered by modern telescopes.

About fifteen years ago, astronomers found that light rays which reach us from distances which they cannot travel in less than many millions of years undergo a considerable shift in color. It is well known that the color of light rays is determined by the wavelength and, for the most distant still-observable astronomical objects, the wavelength appears to be changed by about one-third. This fact may be expressed also by stating that the particles of which light is composed lose about one-third of their energy in traveling such a distance. If they travel a distance twice as large, they would lose one-third plus one-third of the remaining two-thirds, or about one-half altogether and so on, in some kind of geometrical progression.

This fundamental phenomenon, which is known to physicists as the red-shift of light rays, seems to lead to an important conclusion: Even if the universe is infinite, its empirical perceptibility must be confined to finite distances, and these distances cannot be larger than a modest multiple of the distances to which modern telescopes can actually penetrate.

Perhaps science can even go one step further. There are various reasons (some of which are developed in several of the writer's papers) which seem to contradict the common belief in an infinite extension of the world of stars and even lead to quite definite values for the dimensions and the age of the universe.

Enormous as these values are, their relative smallness is surprising. On the ground of these values it would appear meaningless for the scientist to consider distances larger than about ten times the largest actually measured astronomical distances, and likewise it would appear meaningless from the standpoint of astronomy and physics to consider periods more than a few times greater than the age of definite terrestrial minerals.

The barriers which result from atomic indeterminacy and red-shift are, however, by no means the only limitations to physical knowledge. We may easily realize this fact when we consider the final aims of physical science. One of the greatest physicists of the nineteenth century once declared that the goal of physics could be only the exact quantitative description of the observable physical phenomena. Maybe

this great scientist was too modest. Maybe physicists must not necessarily restrict their aims to pure description, but may attempt something like an explanation of the phenomena which they observe.

But what then does the word "explanation" mean in such a statement? It cannot mean more than to reduce the description of a definite phenomenon to the description of another more familiar phenomenon. In other words, it means to establish a relationship between the two observable phenomena.

As a mater of fact, the greatest achievements in the history of physics were discoveries of just such a nature. It might be sufficient to mention the foundation of the mechanical theory of heat, the optical theory of heat radiation, the electro-magnetic theory of light, and—to add a more recent discovery—the analogy between the wave-theory of light and the wave-theory of the motions of elementary particles.

But because in physics explaining merely means establishing of connections, it follows necessarily that questions must remain which the physicist cannot possibly answer. The nature of motion, the origin of motion in the universe, even the nature of electricity are questions of this type.

Physics cannot be expected to solve the riddles of philosophy nor to answer the fundamental questions of the philosophers. All that physics can do is to open new viewpoints for the consideration of philosophical problems and to establish connections between fundamental problems of philosophy. In this, physics has actually succeeded, especially in our century, in many respects, and various previously unexpected relations have been revealed.

Thus, for instance, Einstein established a close connection between the problem of space and that of time. Moreover, he was able to discover a close relation between the problem of mass and that of energy, and later between the problem of gravitation and a basic problem of geometry. Nevertheless, it would be a grave exaggeration to pretend that even Einstein was able to solve any one of these six problems and to answer the questions: What is space, what is time, what is mass, what is energy, what is gravitation, what is the geometry of space?

Another large group of supposedly fundamental and often-raised questions must appear meaningless to the physicist for the following simple reason: We cannot, on the one hand, base the system of physics on the hypothesis of ultimate particles which have no individuality in the usual sense, and then apply the laws of this system of physics to the ultimate particles themselves.

A typical example of a meaningless question of this type is a much discussed dilemma. We know, so say those raising this question, that negative electrical charges mutually repel each other. How is it then

possible, they ask, that electrons which consist of negative electricity hold together and do not explode at all?

From the physical standpoint, this question seems meaningless, because its formulation is wrong. The empirical fact upon which the supposed dilemma is based is that two bodies, each of which contains electrons, repel each other, and from this empirical fact we conclude that likewise two single electrons repel each other. But as soon as we reach the electrons in our reasoning, we must stop. We cannot go further if we believe the electrons to be ultimate particles.

Another typical example of a meaningless problem is the much discussed question as to how, in spite of atomic indeterminacy, the traditional philosophical well-established conception of a physical causality can still be maintained. Atomic indeterminacy does by no means, I believe, exclude a universal causality in elementary processes. Such a causality would, however, presuppose individual properties of the ultimate constituents. Such properties might exist, but it would be a contradiction in itself to believe that such individual properties could be detected by the physicist in the case of those objects which physicists regard as ultimate and to which they apply the fiction of absolute identity. Should therefore a universal causality exist in elementary processes, it could be concerned only with such properties, quantities, and causes which must remain concealed from physical exploration.

The question of elementary causality thus also appears as one of the many problems which lie beyond the limitations of physical knowledge and can be the topic only of philosophical research and philosophical truth.

Notre Dame University,
September 6, 1940.

## ARISTOTELIAN COSMOLOGY

Stanley J. Bezuszka, S.J.

The importance of the Philosophy-Science Department was aptly confirmed at the recent National Science Convention by the special attention given to its problems in the opening Presidential Address. At a time when a comprehensive enumeration of the splendid achievements of Jesuit scientists during four hundred years of research would have been considered appropriate, and an elaborate account of the advancement in the specialized branches of science familiar to the President understandable, the choice of the subject actually delivered singled out the outstanding modern problem in science: the application of immutable and universal principles to the individual facts acquired from particular experiments. This aroused questioning atti-

tude toward the nature of the world about us comes now from the serious inquiries of men who are becoming dissatisfied with merely the tabulated readings of experiments. They are beginning to seek the rational principles hidden in the countless laboratory data sheets so carefully hoarded for the past years. They are striving to distil a fraction of the compendium of truth to answer this mysterious universe they never cease to admire, analyze and measure and yet never fully understand.

In spirit at least, this present tendency is not radically different from the Ancients' insistence and pursuit of a synoptic world view. And because impartial study has revealed an Aristotle who was neither a dogmatic idealist constructing a universe with nothing but the categories of language, nor yet a blind devotee of empiricism, an examination of his works will present a lesson in balanced scientific method. Aristotle was a scientist and a philosopher, a combination of two temperaments indispensable for a complete understanding of reality. He was both the observer and constructor, scrupulously attempting to ally and combine the study of facts with the effort to make them intelligible.

However, this Aristotelian Cosmology will not be taken merely in its narrow outlines. Let it rather be an organic system that began with Aristotle, thrived under the Schoolmen who broadened, corrected and amplified its scope, and now is the heritage of the modern scientist who in spite of his devotion to pointer-readings should reaffirm his instinctive desire to get beyond their symbolism. Modern physics is not incompatible with Aristotelian or Scholastic metaphysics. Variations in the disciplines exist only because science expresses its concepts in a language of transposed meanings with little attempt to pursue logical analysis to its ultimate stage, or because it has adopted a false philosophy. Modern metaphysics, not modern physics is at odds with Aristotelian and Scholastic Cosmology.

Historically, this cleavage between philosophy and science occurred in the sixteenth century during the Renaissance. The outstanding feature of the new intellectual activity, especially in science, was its insistence on experiment and derision of the empty speculations of preceding centuries. As science developed, the appeal of quantity began to dominate the appreciation of quality, until the whole process of scientific inquiry became enamored of measurement and the copying of numbers with mathematical manipulation of data. The momentum of interest in this limited outlook of nature increased by the added impulse of the growth of the specializing scientist. There arose a justifiable scorn among the specialists for the philosopher's encyclopedic ambitions. And to men who believed it expedient to limit themselves to a subdivision of a subdivision in scientific research, the attempt of a single mind to interpret and coordinate the entire field of knowledge seemed unreasonable. They voiced their disapproval

by sarcastic observations that 'what was spread out so far, must be pretty thin in most places.'

In reality, when these men condemned Aristotle and the Schoolmen, they objected to the speculating extremists in those camps, not realizing that their own critical vehemence was to be the cradle of a new race of experimental extremists. If they had only studied Aristotle's unifying method of approach to scientific inquiry, instead of belaboring some of the misguided practices prevalent during that age, a more balanced research would have resulted. Aristotle in his own period realized the need of experiment as a stepping-stone to consistent theory, and stated his conviction in a doctrine applicable to all centuries:

> "Lack of experience diminishes our power of taking a comprehensive view of the admitted facts. Hence those who dwell in intimate association with nature and its phenomena grow more and more able to formulate, as the foundations of their theories, principles such as to admit of a wide and coherent development; while those whom devotion to abstract discussions has rendered unobservant of the facts are too ready to dogmatize on the basis of a few observations."[1]

This realization of the wide branch of knowledge open to conquest by the coordinated effort of experiment and interpretation was fostered and encouraged by Aristotle and the Scholastics. Only the past prevailing idolatry of experience has unbalanced the sane process that endeavored not merely to calculate the course of the world, but to understand it.

As an illustration of the opposition in concepts that resulted from the separation of philosophy and science, we might take the problem of Causality. This word has been a double-edged sword repeatedly used by unscientific philosophers to slash adherents of science, and by unphilosophic scientists to browbeat metaphysicians. In the traditional philosophic sense, a cause denoted a physical agent, which by its action brings into existence something that previously did not exist. But from the sixteenth century on, when science pledged its all embracing allegiance to quantitative relations, this notion of causality was modified. Scientists sought the numerical expression of causes, introduced some idea of an invariable sequence, then ventured on a prediction, and with the limited accuracy of their knowledge of microcosmic events, the notion of Causality developed into one of predictability. Now when sub-atomic researches showed that in the microcosmic world, practically few physical relations could be predicted with perfect mathematical certainty, science unequivocally rejected the principle of Causality. If the above transition in ideas is carefully analyzed, there appears to be no problem whatsoever. Science is priv-

1. "De Generatione et Corruptione", Bk. I. Ch. 2. [ 315 ] Harold H. Joachim.

ileged to adopt, modify and even legitimately change the concepts inadequate to represent its findings. What can be critized is the lack of philosophic sense in the first instance, in deliberately transforming the definition of a standard term to one of a limited and not completely precise meaning.

An analogous difficulty, which has introduced confusion in the precision of thought, deals with the whole discussion of inertia in its connection with matter. When inertia was first taken as the measure of mass, and therefore the numerical expression of the 'quantity of matter' in a body, no question was raised as to whether inertial resistance really was an adequate and suitable property for the measurement of the amount of matter in a body. The issue was prematurely forced when advanced experimentation with the electron showed that its inertial resistance to electromagnetic forces was not constant under conditions of varying velocities. But scientists, instead of discarding or correcting their previous notions on the invariancy of inertia and therefore its usefulness as a criterion for the measure of the amount of matter in a body, rested satisfied with the conclusion that the amount of matter in a body was a function of its velocity. That some absolute invariant is desirable, to substitute for inertia as the quantitative definition of matter, becomes immediately obvious. But we have yet to be convinced that the use of a term which will eventually militate against the natural reasoning process of the mind finds any justification because it aids to a certain degree the quantization of science .

The discussion thus far, has illustrated two methods of procedure in the prevailing science of the past few centuries. The first dealt with an adopted terminology changed to suit the scientist's needs and then rejected when no longer consistent with facts; the second, with a terminology preserved when its limitations practically necessitated rejection. There is a third branch of division in which a distinction of terms has effected a partial reconciliation between science and philosophy. Perhaps the best example of the latter is the question concerning the Laws of Nature.

Aristotle and Scholastic philosophy have established a solid foundation for the laws of nature in the principles of causality and sufficient reason. The philosopher who observes a constancy and ordered sequence among phenomena in similar circumstances, argues from his system to the existence of something in the being that causes it to act in a defined manner. From constancy, he logically proceeds to necessity, then to the internal principle of activity governed by this necessity, and finally to the Nature of the being upon which he bases the validity of his statement of the Laws of Nature. The scientist, on the other hand, is engrossed merely with the end term or effect of the constancy in behavior which he observes in the universe. He cannot numerically tag the tendencies and potencies which the philosopher

maintains to be inherent in the acting agent. But rather than deny their existence, he prescinds from the question, and in the abstraction limits his investigation to the application of the operational viewpoint, to reduce the effects of the law to a quantitative value, to give an approximation and not the final analysis of nature. Therefore, when a scientist states that scientific laws would be more appropriately characterized as generalizations of experience had to the present moment, he logically denies the applicability of his law, with any degree of certainty, beyond his field of experience. With this limitation, his physical law (or more generically, his Convergency of Scientific Investigation) severs all rational connection between experienced and non-experienced facts, and in place of physical certitude, he is left with a varying degree of probability or at most with only a pragmatic certainty.

But this attempted confinement to one aspect alone, though theoretically admissible, is practically untenable. Every scientist is a rational being with all the corresponding attributes of a rational nature. He has an intellect and the power of reason so that willingly or not, this reason pursues experience and ever seeks to formulate cold, logical deductions from collected data. Only a galvanometer or a senseless laboratory instrument could act the ideal and impartial fact pointer that the scientist frequently assumes himself to be. Confirmation of this is more and more evident by the increased philosophic speculation found in a variety of scientific literature.

Though it is encouraging to note the beginnings of a deeper insight and a solid study of the universe among many scientists, still no real progress will be made until the scientific outlook rests again on Aristotelian tenets and the unified Scholastic concept of Nature according to ultimate principles. This revised attitude of mind will not come without a struggle. The pursuit of the problems of Cosmology must be cultivated with feelings of respect for their importance, of awe for their vastness, and of some appreciation for the power of the mind in formulating correct solutions. The healthy industrialism of science and the hard, cold business logic of the age, which frowns upon any preoccupation with ultimates, will present the greatest obstacle. To this mentality, the present investigation, which is in no way or sense vocational, seems useless and sterile. We are therefore forced to include this subject among the luxuries rather than the necessities of life. But if this discipline be a luxury, it is a luxury that finds equal footing with the arts, for it is an element of a higher life. It may not contribute immediately to making a living; but it will help to fashion a fuller life.

# ASTRONOMY

## A NARRATIVE OF THE 1940 ECLIPSE EXPEDITION TO PATOS, BRAZIL

(*Total Eclipse of the Sun, October* 1, 1940)

Rev. Edward C. Phillips, S.J.

On Wednesday, November 20, 1940 a luncheon reception was held at the Headquarters of the National Geographic Society in honor of the members of the Expedition. To welcome them on their safe return from Patos, and to hear from each one of them a brief account of his own part in the work of the Expedition, some twenty guests were invited; these included noted scientists, heads of learned societies and institutions, and the Minister from Brazil in whose country the party was stationed for the eclipse observations. As Father Paul A. McNally, S.J., Director of the Georgetown College Observatory, was a member of the eclipse party, it was natural that the President of Georgetown University was invited; as Father O'Leary was unavoidably absent from Washington at that time, he sent in his place Father Edward C. Phillips, S.J., a former Director of the Observatory.

On arriving at the National Geographic Society Building, each of the guests was introduced to the various members of the expedition. These were:

Dr. I. C. Gardner, of the Bureau of Standards, Director of the Expedition, Fr. Paul A. McNally, S.J., of the Georgetown College Observatory, Dr. C. C. Kiess, of the U. S. Bureau of Standards, Dr. E. O. Hulburt, of the Naval Research Laboratory, Mr. Gilliland, of the U. S. Bureau of Standards, Mr. R. H. Stewart, Photographer of the National Geographical Society.

At the conclusion of the luncheon, a short address of welcome was made in the name of the Geographic Society by its Vice President, Mr. J. O. LaGorce, after which each of the members of the Expedition was introduced very briefly by Dr. L. J. Briggs of the U. S. Bureau of Standards.

There follows the gist of each one's account of the work entrusted to him and of the success or lack of success of his part of the eclipse program.

Dr. Gardner, as Director of the Expedition, gave a brief description of the preparations preliminary to the expedition, the site, the conditions of housing, etc., and the general outcome of the work. He

said this expedition was one of contradictions: the site selected had an almost perfect record for dry weather and clear skies for that part of the year at which the eclipse took place, but contrary to statistical predictions there were several heavy rains during the days of preparation, and on the day of the eclipse itself, the sky was cloudy. Another contradictory aspect, but a most welcome one, was that the members expected to be subjected to the usual hardships of housing, food, etc. encountered on such distant expeditions, but on their arrival found that they were to be housed in most comfortable quarters, with the conveniences of modern plumbing, etc.; and took their meals in a nearby hotel of the first class. Again, the instruments, instead of being set up at a distance from such convenient living quarters were erected in the yard and right under the windows of the quarters in which they lived. Another unusual experience was that the native townsfolk were very skeptical about the whole thing and were very doubtful whether the eclipse would take place at the predicted time: when it did take place on schedule there arose from the admiring multitude such shouts of joy and approbation as could hardly be equaled in enthusiasm by the cheering at a political convention.

The instrumental equipment was excellent, probably not surpassed by that at the disposal of any previous expedition. (Note: As Dr. Gardner was responsible for much of the design of the instruments and was in charge of the construction of the equipment which was sponsored by the National Geographical Society and built at the Bureau of Standards, modesty prevented him from saying much about its perfection.)

Though to their great disappointment clouds vied with the Moon in hiding the Sun and shut out the view of the phenomenon during the period of totality, Dr. Gardner estimated that the expedition secured about a 30% success. The details of this success he left to the other individual members to describe.

He added an encomium of the Brazilian civil authorities, of the staff of the Cotton Gin where the expedition was housed and their instruments set up, and of the entire neighboring populace, by all of whom they were treated with the most perfect courtesy and were helped in the most efficient way in all their needs.

Father McNally, the second speaker, after thanking the National Geographic Society's officers for the opportunity given to Georgetown University to participate in the expedition, said he thought justice demanded that he add to Dr. Gardner's estimate of the instrumental equipment by stating that not only was it not surpassed by any previous one, but that it was definitely and notably superior to that at the disposal of any expedition from any country in the world.

He remarked that the Naval Observatory had planned an expedition, but that the defense program of the nation had necessitated

the cancellation of their plans. The chief interest of the Naval Observatory lay in a more accurate determination of the times of contacts of the Sun and Moon, which would also help to a more accurate determination of the absolute diameters of both the Sun and the Moon. The Naval Observatory authorities requested Fr. McNally to obtain, if possible, the observations which it had been intended to secure for the above purpose. The Georgetown College Observatory astrographic telescope was specially adapted to this purpose and it was planned to take as many photographs as possible of the progress of the Moon's disc over that of the Sun. The best previous set consisted of 48 images on 48 separate plates; owing to the character of the emulsions then in use and the brilliance of the unobscured portion of the sun, it was necessary to leave the plates highly under-developed in order that the fogging of the background due to scattered light would be at a minimum. The results were good but left room for improvement: the intersections of the two arcs (of Sun and Moon) instead of being sharply defined points (arrowheads) were ill-defined rounded terminals and in measuring the plates it was necessary to estimate the center of these rounded ends of the crescents.

On the present expedition a greatly improved emulsion recently developed by the Kodak Company, namely Microfile, was used, and this for the first time was applied to glass plates (8x10 inches) instead of on film as heretofore. The excellent astrographic Ross lens, 3 inches in diameter, was used at full aperture; in order to cut down the brightness of the sun's image a filter made by the deposition of a thin film of silver on an optically flat glass plate was placed in front of the lens, thus allowing only blue and some ultra-violet light to pass through. Through experiments made during the week previous to the eclipse it was found that as many as sixty images could be secured on a single plate and this without any fogging of the background even on full development. Those who have seen the plates marvel at the clearness of the background and at the perfect sharpness of the images, giving spearhead definition to the common intersections of the arcs and consequently allowing very accurate measurements of the lengths of the successive common chords from which the instants of the four contacts can be determined with high accuracy. Of course the times of the successive exposures were recorded on the chronograph which was operated in series by the same current which controlled the photographic shutter. This part of the program may therefore be considered as 100% successful; even though floating clouds cut out a few of the exposures there still remain on the four plates a total of some two hundred measurable images.

Dr. Kiess then took up the narrative and described his part of the work which was to obtain spectrographic plates at the various phases of the eclipse. The spectrograph, which has been especially constructed for this eclipse is the most powerful and effective one so far

developed. The reflecting grating specially made for this work was 6 inches in length, ruled with 30,000 lines to the inch. The brilliance and sharpness of the spectral images produced are such that a much shorter exposure time than formerly needed can now be used. The actual exposure time used was one-third of a second resulting in a considerable over-exposure for the brighter parts of the spectrogram. For future work the exposure time can be reduced to about one-tenth of a second. Naturally the clouds interfered with the spectrographic program; however there were some openings and some thin portions of the floating cloud mantle, and successive exposures were made in the hope of catching a favorable moment. In fact this hope was fulfilled near the time of third contact. On developing the plates he found that one of them was a real success; the clouds at that moment in the region of the sun were sufficiently transparent to allow enough light to come through to give a good spectrogram showing the flash spectrum as well as the dark-line spectrum. The measurements of this spectrogram are not as yet complete but the results so far obtained clearly indicate that the perfection of this exposure will enable definite corrections to be made to the previously accepted wave lengths of some of the so-called coronal lines.

Dr. Hulburt's share in the program was to have been a determination of the brightness of the sky at a distance from the sun during totality. The clouds prevented any observation of scientific value along this line.

Mr. Gilliland was more fortunate than others since his allotted work was independent of cloudiness or sunshine. He was to measure the variation in ionization of the various layers of the ionisphere which play so important a part in short wave radio propagation.

The last to speak was Mr. Stewart who accompanied the expedition to make a photographic record by movies and still pictures of its activities both scientific and otherwise. Many of these records were taken on full-color film and have the beautiful artistic perfection made so familiar to millons of readers through the illustrated pages of the National Geographic Magazine. Of scientific value is the photo-history of the site of the expedition, of the erection, adjustment, etc. of the instruments. Among the pictures shown to the guests after the luncheon was one of the diamond ring effect at third contact. This is considered probably the best picture ever obtained of this phenomenon; owing to the use of color photography and the thin film of clouds through which the picture was caught, there is a distinct prismatic halo about the "diamond"—a rainbow setting to a beautiful jewel.

It is clear therefore that the expedition's labors were not as poorly repaid in results as the first newspaper reports would lead one to suppose. We will wait with interest a final scientific evaluation of the observations.

There were several interesting side-lights thrown on the adventure by one or other of the speakers. One of these shows the occasional advantage of a "practical" mind over the scientific one. The gasoline engine running one of the dynamos (the one used to supply current for the radio apparatus) functioned very poorly for a considerable time during the period of preparation; it would heat up so abnormally as to make it necessary to stop it. Renewed lubrication, dismantling and reassembling of its parts produced no improvement. It was then decided that this misadventure was due in general, of course, to the laws of nature, but more particularly to the Laws of Brazil, one of which is that all commercial gasoline must be mixed with 20% of alcohol. Now *that* engine was built to operate on pure gasoline—and alcohol, however useful under other circumstances, was an adulteration when put into the gasoline. The "scientists" therefore determined that either a sufficient supply of unadulterated fuel must be bought which was not practical, or else the alcohol must be separated out; fractional distillation based on the known difference of the boiling points of the two parts of the mixture at once suggested itself—unfortunately there was not at hand the proper equipment for the effective and safe purification by such means. The local dealer in automotive supplies heard of the difficulty and said that he thought he might be able to help; they went to his gas station where he took a bucket, half filled it with the adulterated gasoline, and to the surprise if not the dismay of the scientists, went to the hydrant and added a supply of water! After stirring the mixture and letting it settle, he syphoned off pure gasoline, leaving the offending alcohol imprisoned by solution in the water. After that the engine worked perfectly. But even engines can be temperamental, for laws of nature and Brazil to the contrary, the other similar engine did not only not over-heat with the adulterated gasoline but worked better than ever before; regaled with 20% of alcohol it seemed to enjoy work and leaped to it whenever given a chance.

Another incongruity was observed in relation to the radio equipment; this was of the portable type and was housed in an automobile trailer which had been found the most convenient manner of transportation in previous field work in the U.S.A. On arrival at Recife, the port of disembarkation, it was found that the roads which the party had been informed were good gave clear evidence that the term "good roads" has different local meaning in that part of Brazil from what it has up here; in fact the condition of the roads consequent upon the ravages of the rainy season made them so impassable for the trailer that it was shipped some 150 miles by train to the end of the railroad line, and from there to Patos, another 200 miles, it went in ease mounted on a sugar-plantation truck. On the way back, they did not take the trouble to transfer it to the railroad but sent it all the way by truck. In the meantime they had received a cablegram

from a well-known tire manufacturer asking the photographer to take a picture of the trailer on the Brazilian road with the name of the tire clearly in view—as the tire never touched the Brazilian road, the manufacturer never got his picture.

Several of the pictures, which were exhibited after the luncheon, show a youngster about three or four years old, Eudavar by name, apparently conversing at different times with Father McNally; this youngster became a fast friend at the first meeting and joined Fr. McNally every time the party went to the Hotel for meals; they *talked* to each other a great deal but never really *conversed* since neither could understand a word the other was saying, Portuguese being unknown to one of the friends and English to the other.

GEORGETOWN UNIVERSITY,
Washington, D. C.

# BIOLOGY

## THE EFFECT OF SEALING PARAMECIUM IN VASELINE ENCLOSURES ON THE PHYSIOLOGY OF PARAMECIUM

(Abstracts of Three Papers to be Presented by Title at The Philadelphia Meeting of The American Society of Zoologists Dec. 30-Jan. 1, 1941)

Rev. John A. Frisch, S.J.

I. The Effect on The Rate of Pulsation of The Contractile Vacuoles.

This method of mounting paramecium for observation has been stated to result in a decrease in the rate of pulsation of the contractile vacuoles to such an extent, that, when an individual is observed for several consecutive pulsations, the decrease in the rate of pulsation is clearly discernible. (Herfs, A. 1922 Arch. Protistenk., 44,227.). 753 individuals of paramecium caudatum and paramecium multimicronucleatum, sealed in vaseline enclosures, have been observed for a total of 20,413 pulsations. Considering any change of less than one second in the time interval between pulsations of no significance, the following results were obtained: Of 247 individuals observed, each for an average of nine consecutive pulsations, 59.5% did not alter the rate of pulsation, 11.8% increased the rate, and only 28.7% decreased the rate. Of 506 individuals observed, each for an average of 36 consecutive pulsations, 88.9% did not alter the rate of pulsation, 8.3% increased the rate, and only 2.8% decreased the rate.

These results indicate that a decrease in the rate of pulsation occurs in only a small percentage of the individuals, and that, the larger the number of consecutive pulsations observed, the smaller this percentage becomes. The added fact that 11.8% and 8.3% of the individuals increase the rate of pulsation indicates that the decrease in the rate of pulsation in some of the individuals cannot be attributed to the enclosure in vaseline.

II. The Effect on The Rate of Fission.

129 Vaseline enclosures, containing from one to ten individuals of paramecium caudatum or paramecium multimicronucleatum were observed daily until all the individuals in the enclosures had died. In 31% of these enclosures no fission occurred of any of the individuals, though in some of the enclosures the individuals remained alive for as

long as 65 days. In the remaining 69% of the enclosures the maximum number of fissions occurring in any of the enclosures during a period of 155 days was seven, and many of the individuals did not divide.

The above results indicate that fission is either entirely inhibited or is greatly delayed in vaseline enclosures. The extent of the inhibition is shown by the fact that 80 individuals survived for from 10 to 65 days without dividing; the extent of the delay in fission is indicated by the fact that 18 individuals divided after a delay of from seven to 39 days. Evidence indicates that shortage of food in the vaseline enclosures is the factor operating in both the inhibition and the delay in fission.

III. The Effect on Longevity.

The following vaseline enclosures of paramecium caudatum or paramecium multimicronucleatum were set up and each was observed daily until all the individuals in the enclosures had died.

(1) 56 enclosures started with one individual;

(2) 30 enclosures started with from 2 to 10 individuals;

(3) 56 enclosures started with from 1 to 7 individuals and an abundance of unicellular green algae.

In 18% of the enclosures of (1), 6.6% of the enclosures of (2), and 1.8% of the enclosures of (3) the animals died within 24 hours. In 63% of the enclosures of (1) the animal or its progeny survived from 5 days to 54 days; in 90% of the enclosures of (2) the animals or their progeny survived from 5 to 39 days; in 98.2% of the enclosures of (3) the animals or their progeny survived from 5 to 155 days.

These results indicate: a) a greater initial mortality of the (1) enclosures, started with 1 individual, as compared with the (2) enclosures, started with several individuals, probably due to a growth factor in (2); b) a greater survival time of the individuals in (1), provided they weather the first 24 hours, probably due to a food factor; c) a decrease in the initial mortality and a great increase in the survival time of the (3) enclosures, due probably to the liberation of oxygen and the utilization of excretory products by the algae.

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# CHEMISTRY

## MOLECULAR WEIGHT DETERMINATION BY ISOTHERMIC DISTILLATION *

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In the course of systematic investigations as to the usability of most known micromethods of molecular weight determination, the method described herein (5, 6) was developed. The method is a rigid application of the observations of L. Errara (1), who found that the volumes of suspended droplets of salt solution in a closed system invariably increased, whereas those containing the solvent alone did not. Following the suggestion of the same investigator to study this behavior quantitatively, G. Barger (1, 9) developed his ingenious "microscopical method of determining molecular weight." In this method "a solution of known strength of the substance, the molecular weight of which is unknown, is compared with standard solutions of a substance of known molecular weight, a series of drops taken alternately from the two solutions, being introduced into a single capillary tube." The chief interference is the mixing of the droplets either during the filling operation or on standing. The molarities used were from 0.1 to 0.25 M solutions and an accuracy of plus or minus 10% was claimed. The method underwent several modifications notably by K. Rast (8) who only used one drop of each of the two solutions and measured not only the actual volume of the drops, but the movement of the air bubbles separating the two solutions. The molarities employed varied from 0.2 to 1 M solutions. A. Friedrich (3, 4, 7) in avoiding the rather high concentration in the foregoing procedure, fixed the two drops by eliminating terminal air spaces, while J. R. Spiess (12) developed an improved method of filling the capillary. Further modifications involve the use of a U-shaped capillary (2), actual determination of distillate (10) and adaption of the method on a macro scale (11). The present method possesses several advantages over Barger's method and its subsequent modifications, i.e.: the two solutions cannot mix, the sample can be recovered and the changes in volume are much larger and permanent. The apparative arrangement and technique involved is of utmost simplicity.

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## Principle

This method of determining molecular weights is based upon isothermic distillation of volatile solvent from a solution of lower molarity to a solution of higher molarity. In a closed system this produces measurable changes in the volumes of such solutions. These volume changes are determined by following under a low power microscope the changes in the position of the meniscii of the two solutions contained in separate capillaries. By appropriately pairing standard solutions of various but known molarities with a solution of known concentration of a test substance in the same solvent and tabulating the ensuing changes in the volumes of the standard solutions the point of maximum volume change is ascertained. This point of maximum volume change indicates the climatic equilibrium point (where no further change takes place) of the molarity of the test substance and forms the basis for the calculation of the molecular weight of the unknown.

## Apparatus

Microscope. An ordinary low power microscope is used. (Objective 4.6x ocular 7x). The eyepiece carries a micrometer scale marked from 0 to 50. These fifty divisions correspond to 1.5 mm, therefore 1 division corresponds to 0.03 mm.

Glassplate. A rectangular glassplate about 12 cm. long, 4 cm. wide and 2 mm. thick which possesses five parallel transverse lines situated near the center of the plate. The lines must not be more than 0.03 mm. thick and should be 3 mm. apart and they are appropriately marked (I, II, III, IV, V).

Capillaries. The capillaries are 10-12 cm. in length and about 1.5 mm. in inner diameter.

Colored Glass Thread. Not more than 0.1 mm. in diameter.

Desiccator Tube. This is ordinary glass tubing sealed at one end. It is 5-6 mm. in diameter and 15 cm. long.

Glass Wool. Pliable pyrex glass wool is best used, although ordinary cotton might be substituted.

Adhesive Tape. Ordinary surgical adhesive tape, 1 inch in diameter is entirely satisfactory.

Volumetric Flasks. Glass stoppered, 2 250ml., ½ doz. 100, 50 and 10 ml., 1 doz. 25 ml. and 1 2ml. capacity (similar to the tare bottles for the absorption tubes).

Pipette. 1 ml. capacity, calibrated 0.1 ml.

Hand Centrifuge. Ordinary, as used in clinical analyses, equipped with 2 metal tubes. The capillaries are inserted directly into these metal tubes. Violent centrifuging is unnecessary, a single turn of the handle usually suffices

Vacuum Pump. An ordinary tap water pump producing a vacuum of from 15-20 mm. is adequate.

## Reagents

Solvent. Ethyl alcohol (95%) 1 liter. Since the solvent for the standard and the sample must be the same, a sufficient amount should be available not only for the preparation of the standard but also for the various unknowns to be examined. Any other organic solvent might also be used (acetone, pyridine, etc.)

Standard Solutions. Ten standard solutions: 0.2; 0.15; 0.1375; 0.125; 0.1; 0.0875; 0.075; 0.0625 and 0.05 molar. These standard solutions are best prepared as follows: first 250 ml. of 0.2 M solution is prepared by dissolving an appropriate standard sample, preferably a colored substance, accurately weighed on a macrobalance, in a solvent suitable for both, the standard and the test sample, (ethyl alcohol, acetone, pyridine, etc.).

Exactly one half of this standard solution is transferred to another 250 ml. volumetric flask, using a 100 ml. and a 25 ml. volumetric flask for the transfer. These two flasks are then rinsed several times with the original solvent and these rinsings are added to the solution followed by addition of more solvent to bring the solution up to the mark. This then constitutes the 0.1 M standard solution. Twenty-five ml. of the original 0.2 M solution are transferred into 100 ml. volumetric flasks and following the above rinsing and filling up procedure, 100 ml of the 0.05 M standard solution are obtained. Fifty ml. of the same 0.2 M solution are transferred to another 100 ml. volumetric flask, but this time for the rinsing and the filling up procedure portions of the 0.1 M solution are used to yield 100 ml. of the 0.15 M standard solution. Thus three more primary standard solutions (0.05, 0.1 and 0.15) are obtained.

The secondary standard solutions (0.0625; 0.075; 0.0875; 0.1125; 0.125 and 0.1375) are obtained by mixing equal quantities of the appropriate primary standard solutions, i. e.: 50 ml. of the 0.05 M solution are mixed with an equal amount of the 0.1 M solution to give 100 ml. of the 0.075 M standard solution. Twenty-five ml. of this solution are again diluted with an equal amount of the 0.05 M primary standard solution to yield 50 ml. of the 0.0625 M standard solution. Twenty-five of the same 0.075 M solution are mixed with 25 ml. of the 0.1 M solution to form 50 ml. of the 0.0875 M standard solution Fifty ml. of the 0.15 M primary standard solution are introduced into

a 100 ml. volumetric flask and after rinsing of the 50 ml. transfer flask with portions of the 0.1 M solution and filling up the 100 ml. flask to the mark with portions of the latter solution, 100 ml. of the 0.125 M standard solution are obtained. To prepare 50 ml. of the 0.1125 M solution, 25 ml. of the 0.1 M solution are mixed with an exactly equal amount of the 0.125 M solution and finally 25 ml. of this solution are mixed with 25 ml. of the 0.15 M primary standard solution to yield 50 ml. of the 0.1375 M standard solution.

The ten standard solutions as prepared above are transferred and stored in properly labeled 25 ml. volumetric flasks.

## Procedure

Preparation of the Sample Solution. The sample solution might be prepared on a macro (above 100 mg. substance (Table III)), semi-micro (above 30 mg. substance (Table I)), or on a micro scale (Table II). In the latter case, 4-6 mg. of the sample are weighed in the long-stem weighing tube and transferred to a glass-stoppered weighing bottle. This bottle is then weighed on an ordinary analytical balance to within 1 mg. After the addition by means of a pipette of approximately 0.5 ml. of the identical solvent as used for the standard solution, the glass stoppered bottle is weighed again while stoppered. The weight of the solvent thus found is divided by its specific gravity to give the correct volume. A precision delivery pipette might be used, if the pipette is standardized for reproduceable delivery, without rinsing requirements.

Preparation of Capillaries. One of the capillaries is filled to two thirds its length (i. e. 8 cm.) with the solution of the unknown (B) by means of suction by mouth. For volatile liquids it is advisable to have one end of the capillary dipping into the solution, drawn out to a hairline ending (pipet-like). The end of the capillary which is opposite the liquid is sealed in a microburner. After cooling, the solution is centrifuged toward this sealed end by means of a suitable hand centrifuge. No violent centrifuging is necessary; a single turn of the handle usually suffices. Three more capillaries are then filled, sealed and centrifuged in exactly the same manner. Similarly the set of capillaries (A) containing the standard solutions (0.2, 0.15, 0.1 and 0.05 molar) is prepared. If the standard solution is colorless, each and every capillary is marked by inserting a small colored glass thread (0.1 mm. thick and 2 mm. long) into each and every one of these capillaries before centrifuging. After this, each and every standard solution capillary is paired off with a capillary of the unknown, preferably in such a way that the meniscii of the two solutions (0.05-0.08 ml.) are at the same level (80-100 cmm. solution). Each pair (A and B) is then introduced, sealed and let down, into the desiccator tube. Both capillaries should rest firmly at the bottom of this tube. A wad of

pliable glass wool is then introduced and pushed down into the tube to about 5 mm. below the openings of the capillaries, but well above the meniscii of the solutions. The purpose of this wad is to keep the two capillaries in position. As close as possible to the openings of the capillaries the desiccator is softened in the flame of an ordinary gas burner. If the solvent used is very volatile (b. p. below 60°C) it is advisable to cool the capillaries with the tube in ice water. The walls of the tube are allowed to collapse and this portion of the tube is then drawn out into a capillary without breaking off the constriction thus produced. The tube is then allowed to cool, if necessary in ice water, and is then evacuated to about 15-20 mm. pressure. An ordinary tap water aspirator pump suffices for this purpose. While the tube is still attached to the aspirator pump the capillary constriction produced previously is once more heated in the gas flame and allowed to collapse completely, thus forming a seal. The desiccator tubes thus prepared are then appropriately marked and set aside in an upright position for several days (four days if ethyl alcohol is used as solvent) for acclimatization.

Mounting of the Filled Desiccator Tubes. After acclimatization, the tubes are mounted on the glass plate. The tube is first placed on the plate in such a way that the meniscii of the two solutions contained in the enclosed capillaries come within the transverse markings. While held in this position, adhesive tape is applied at the two extreme ends of the tube and the tube fastened to the plate. Two or three tubes may be mounted on the same plate.

Method of Heading. Either the liquid column or the air column may be measured. The liquid column (1) is the distance of the solution between the apex of the meniscus and the nearest reference line, situated within the column of liquid. The air column is the distance between the apex of the meniscus and the nearest reference line above the liquid column. The reference lines are distinguished by Roman numerals.

Before taking the readings under the microscope, the position of the meniscus of the standard solution in regard to the nearest reference line is noted (meniscus between reference line I and II etc.). After this, the plate with the mounted tubes is placed on the microscope stage with the liquid columns at the left. The meniscus of the standard solution is brought into focus and then the nearest reference line is sought. Whether to take readings of either the liquid or the air column is decided by whether the reference line within the micrometer scale reading is within the liquid column or above the meniscus of the solution. In case the liquid column is chosen, the microscope is focused at the apex of the meniscus (outermost point of the semicircular sharp shadow), and the plate moved until the zero mark of

the micrometer scale coincides with this point. Then the microscope is focused upon the chosen reference line and the readings noted.

If the air column is chosen, that is, when a reference line above the meniscus is within the micrometer scale range, again the microscope is focused upon the apex of the meniscus in exactly the same way as for the liquid column. The plate then is moved so that this point is at the number 50 of the micrometer scale. Without changing the position of the plate the microscope is now focused on the reference line and reading taken.

Readings are repeated not oftener than every 24 hours in the beginning, and about every 2-3 days thereafter for about ten days. Usually about five readings suffice. An increase in the liquid column is designated at plus, a decrease at minus. An increase in the air column is designated as minus and a decrease as plus. The results are then tabulated or a graph is prepared.

From the table or graph thus prepared it will be noticed that a certain molarity (m) shows a marked increase or reversal from the preceding molarity (n), whereas all the other succeeding or preceding solutions show a more or less constant increase or decrease. That particular molarity constitutes the maximum volume change and indicates that the molecular weight of the test substance lies between the preceding lower molarity (n) and the molarity of this particular standard solution (m).

For finer differentiations, the experiment is repeated using molarities in the range of maximum volume change. If this maximum volume change was at 0.15 M, then the next differentiations would involve the range between 0.15 and 0.1 M. This is done by pairing off these two primary standard solutions as well as the 0.1125, and 0.125 and the 0.1375 secondary standard solutions. Similarly if this maximum volume change took place between the 0.05 and 0.1 molar solutions, the 0.0625, 0.075 and 0.0875 M as well as 0.05 and 0.1 M solutions are once more paired off. In case the maximum volume change occurred, between the 0.15 and the 0.2 molar solution, it is better to prepare a fresh solution of the test sample with lower concentration (c).

CALCULATION:

Molecular weight: Mean Between $\frac{C}{M}$ and $\frac{C}{N}$

C: grams of sample in 1 l. of solvent;

M: molarity of standard solution exhibiting the maximum volume change;

N: molarity of standard solution preceding the maximum volume change.

## Remarks

In the present method it was observed that it is advisable to keep the concentration of the unknown below the concentrations of the standard solutions. In certain types of substances (acids, phenols, etc.) molecular association in associative solvents (benzine, chloroform, etc.) might be encountered. To be safe, it is therefore advisable to carry out molecular weight determination of unknown in two or more different solvents, or mixtures of solvent. For student experiments the system urea (0.6% solution in 95% ethyl alcohol) and azo-benzene has been found extremely satisfactory. The capillaries usually contain from 0.05-0.08 ml. solution and depending upon the concentration this corresponds to 0.3-1.5 mg. of substance.

## TABLE I

Standard Solution: Azobenzene in 95% ethyl alcohol.
(0.08, 0.09, 0.11 and 0.12 molar, 1.4 and 2.18% solutions),

Unknown: UREA in 95% ethyl alcohol.
(0.10 molar, 0.6% solution).

Capillaries filled: May 24th, 1940 (P = 20 mm).
Capillaries mounted; and first reading: May 29, 1940 (T = 20° C).
First observation (second reading): May 31, 1940 (T = 20° C).

Micrometer Readings

| AZOBENZENE | | UREA | | Azobenzene | Urea |
|---|---|---|---|---|---|
| Molar | 1st 2nd | 1st | 2nd | | |
| 0.08 | L II 20 L II 15 | L II 0 | L II 34 | — 5 | +34 |
| 0.09 | L II 3 L II 3 | L III 24 | L III 40 | 0 | +16 |
| 0.11 | L III 34 L III 65 | L II 20 | L II 8 | +31 | —12 |
| 0.12 | L II 20 L II 65 | L II 0 | A II 40 | +45 | —40 |

## TABLE Ia

Second Observation (Third Reading, June 1, 1940, T = 21° C)

Micrometer Readings

| AZOBENZENE | | UREA | | Azobenzene | Urea |
|---|---|---|---|---|---|
| Molar | 2nd 3rd | 2nd | 3rd | | |
| 0.08 | L II 15 L II 15 | L II 34 | L II 41 | 0 | + 7 |
| 0.09 | L II 3 L II 3 | L III 40 | L III 45 | 0 | + 5 |
| 0.11 | L III 65 A IV 20 | L II 8 | L II 6 | +15 | — 2 |
| 0.12 | L II 65 L III 12 | A II 40 | A II 47 | +47 | — 7 |

TABLE Ib

Third Observation. (Fourth Reading, June 3, 1940, T = 24° C)

| AZOBENZENE | | | | UREA | | | | Azobenzene | Urea |
|---|---|---|---|---|---|---|---|---|---|
| Molar | 1st | | 2nd | 1st | | 2nd | | | |
| 0.08 | L II | 15 | L II 11 | L II | 41 | A III | 30 | — 4 | + 29 |
| 0.09 | L II | 3 | L II 8 | L II | 45 | L III | 65 | + 5 | + 20 |
| 0.11 | A IV | 20 | A IV 0 | L II | 6 | L II | 6 | + 20 | 0 |
| 0.12 | L III | 12 | L III 31 | A II | 47 | L I | 42 | + 19 | — 11 |

TABLE Ic

Fourth Observation. (Fifth Reading, June 7, 1940 T = 25° C)

| AZOBENZENE | | | | UREA | | | | Azobenzene | Urea |
|---|---|---|---|---|---|---|---|---|---|
| Molar | 1st | | 2nd | 1st | | 2nd | | | |
| 0.08 | L II | 11 | L II 10 | A III | 30 | A III | 8 | — 1 | + 22 |
| 0.09 | L II | 8 | L II 2 | A IV | 35 | A IV | 10 | — 6 | + 25 |
| 0.11 | A IV | 0 | L IV 40 | L II | 6 | L II | 14 | + 40 | + 8 |
| 0.12 | L III | 31 | L III 60 | L I | 42 | L. I | 45 | + 29 | + 3 |

TABLE Id

Fifth Observation. (Sixth Reading, July 26, 1940. T = 31.5° C)

| AZOBENZENE | | | | UREA | | | | Azobenzene | Urea |
|---|---|---|---|---|---|---|---|---|---|
| Molar | 5th | | 6th | 5th | | 6th | | | |
| 0.08 | L II | 10 | A I 19 | A III | 8 | L III | 24 | — 129 | + 32 |
| 0.09 | L II | 2 | A I 25 | A IV | 10 | A IV | 11 | — 127 | — 1 |
| 0.11 | L IV | 40 | A IV 50 | L II | 14 | L II | 15 | + 10 | + 1 |
| 0.12 | L III | 60 | A IV 15 | L I | 45 | L I | 3 | + 25 | — 42 |

TABLE Ie

Summary: First to sixth Reading, May 29th to July 26th, 1940

| AZOBENZENE | | | | UREA | | | | Azobenzene | Urea |
|---|---|---|---|---|---|---|---|---|---|
| Molar | 1st | | 6th | 1st | | 6th | | | |
| 0.08 | L II | 20 | A I 19 | L II | 0 | L III | 24 | — 139 | + 124 |
| 0.09 | L II | 3 | A I 25 | L III | 24 | A IV | 11 | — 128 | + 65 |
| 0.11 | L III | 34 | A V 50 | L II | 20 | L II | 15 | + 116 | — 5 |
| 0.12 | L II | 20 | A IV 15 | L II | 0 | L I | 3 | + 165 | — 57 |

TABLE If

POINTS OF REVERSAL AND MAXIMUM VOLUME CHANGES

| | Mm | Mn | c/m | c/n | Molecular Weight Found | Mean | Calcd. |
|---|---|---|---|---|---|---|---|
| 1st Observation: (I) | 0.11 | 0.09 | 54.5 | 66.0 | 60.3 | | 60.0 |
| 2nd Observation: (Ia) | 0.11 | 0.09 | 54.5 | 66.0 | 60.3 | | |
| 3rd Observation: (1b) | 0.11 | 0.09 | 54.5 | 66.0 | 60.3 | | |
| 4th Observation: (1c) | 0.11 | 0.09 | 54.5 | 66.0 | 60.3 | | |
| 5th Observation: (Id) | 0.11 | 0.09 | 54.5 | 66.0 | 60.3 | | |
| Summary (Ie) | 0.11 | 0.09 | 54.5 | 66.0 | 60.3 | | |

TABLE II

Standard Solution: Azobenzene in 95% ethyl alcohol. (0.1125, 0.1250, 0.1375 and 0.15 molar).

Unknown: Urea, 6.162 mgs. dissolved in 0.6955 g. (0.8522 ml.) 95% ethyl alcohol, (0.724% solution, by volume).

Capillaries filled: June 15th, 1940

Readings: 1st: June 19, 1940 T=24°C
2nd: June 20, 1940 T=25°C
3rd: June 21, 1940 T=24°C
4th: June 24, 1940 T=23°C

| Maximum volume changes: | Mm | Mn | c/m | c/n | Molecular Weight Found | Mean | Calcd. |
|---|---|---|---|---|---|---|---|
| 1st Observation: | 0.1250 | 0.1125 | 58.0 | 64.3 | 61.6 | | 60.0 |
| 2nd Observation: | 0.1375 | 0.1250 | 52.6 | 58.0 | 55.3 | | 60.0 |
| 3rd Observation: | 0.1250 | 0.1125 | 58.0 | 64.3 | 61.6 | | 60.0 |

TABLE III

Standard Solution: Azobenzene in 95% ethyl alcohol. (0.06, 0.08, 0.09, 0.11, 0.12 and 0.13 molar)

| SUBSTANCES: | c | Mm | Mn | c/m | c/n | Molecular Weight Found | Mean | Calcd. |
|---|---|---|---|---|---|---|---|---|
| Benzoic acid | 12.21 | 0.11 | 0.09 | 111.0 | 134.5 | 122.8 | | 122.0 |
| Benzylcinnamate | 21.172 | 0.09 | 0.08 | 235.2 | 264.6 | 249.9 | | 238.3 |
| p-Benzyl-phynol | 19.556 | 0.11 | 0.09 | 177.7 | 217.2 | 197.5 | | 184.2 |
| p-hydroxyacetophenone | 12.348 | 0.11 | 0.09 | 112.2 | 137.2 | 124.7 | | 136.0 |
| o-nitrophenol | 13.332 | 0.11 | 0.09 | 121.1 | 148.1 | 134.6 | | 139.1 |
| Pyrogallol | 11.348 | 0.11 | 0.09 | 103.1 | 126.1 | 114.6 | | 126.0 |
| Thymol | 17.044 | 0.12 | 0.11 | 142.0 | 154.8 | 148.4 | | 132.2 |
| Vanillin | 13.728 | 0.11 | 0.09 | 124.7 | 152.5 | 138.6 | | 152.1 |
| vic. Xylenol | 11.848 | 0.11 | 0.09 | 107.7 | 131.6 | 119.6 | | 122.1 |

## TABLE IV

Standard Solution: d-glucose in water.
(0.015, 0.010, and 0.005 molar)

Unknown: Sucrose in water
(0.010 molar, 0.34% solution).

Capillaries filled: July 12th, 1940 P = 40 mm
1st Observation: July 15th, 1940 T = 25° C
2nd Observation: July 17th, 1940 T = 27° C
3rd Observation: July 19th, 1940 T = 28.5° C
4th Observation: July 22nd, 1940 T = 31° C
5th Observation: July 24th, 1940 T = 29° C

MICROMETER READINGS

| Molar | 1st | 2nd | 3rd | 4th | 5th | Diff. |
|---|---|---|---|---|---|---|
| 0.005 | L III 24 | L III 16 | L III 6 | L III 1 | | —23 |
| 0.01 | L III 4 | L III 4 | L III 4 | L III 3 | L III 2 | — 2 |
| 0.015 | L II 45 | | | | L II 27 | —18 |

## TABLE V

Standard Solution: sucrose in water.
(0.015, 0.010 and 0.005 molar).

Unknown: d-glucose in water
(0.01 molar, 0.18% solution).

Capillaries filled: July 12th, 1940 P = 40 mm
1st Observation: July 17th, 1940 T = 27° C
2nd Observation: July 18th, 1940 T = 27° C
3rd Observation: July 22nd, 1940 T = 31° C
4th Observation: July 24th, 1940 T = 29° C

| Molar | 1st | 2nd | 2nd | 3rd | 4th | Diff. |
|---|---|---|---|---|---|---|
| 0.005 | | L III 20 | L III 20 | L III 30 | | +10 |
| 0.010 | L III 2 | L III 2 | L III 2 | L III 2 | | 0 |
| 0.015 | L III 4 | L III 1 | L III 1 | L III 1 | A III 5 | — 9 |

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## SWIMMING POOL NOTES

Rev. Bernard A. Fiekers, S.J.

The writer was privileged to have had the general superintendence of an outdoor pool in the spring and early summer of 1940. A record of some of the lessons learned, both chemical and mechanical, may be of use to others.

The fact that the "plunge" was out-of-doors created some peculiar problems. Besides, there was no circulating system, no vacuum cleaner, no smooth tiled walls,—just a blanched concrete tank, with pavements, railing of stone at the back, and bath house in brown and stucco with a red roof. It is man's artificial transition from beautiful garden terraces to an idyllic woodland background that had become grotesque to a degree from the New England hurricane of 1938.

It is a 69,000 gallon affair, 35x60 feet, averaging 6 ft. in depth, from 3 ft. at the shallower end to 9 ft. depth, 60 feet away under the diving board and tower.

Hibernating the plant was simple enough. It was not drained! A few logs were floated across the narrower dimension at the middle and loosely tied to the sides. That was all. There was no damage from ice expansion, except possibly to the corners of the stairs and platform just below the surface in one of the shallow corners. Probably a great deal of damage that the frosty ground would have inflicted on the floor was avoided in the use of this simple expedient. At any rate, small rifts in the concrete walls, and age-old cracks in the floor had to be retouched before filling in the springtime.

But the preparation of the tank during the last weeks of April and the earlier fortnight in May was quite a different story. The logs were removed and the "sea-cocks" opened. As the waters receded, the walls and floors were vigorously hosed to send the slime that had collected along to the drain. And, lest the drain clog, the last few feet of water were allowed to run off unaided. From 12 to 15 buckets of slime were removed: the rotted leaves and twigs of the late autumn; all was hosed out that could be, and the tank was allowed to bake for days in the hot sun of early May.

Then the slime on the walls flaked and cracked like autumn leaves. Hosing alternated with sun-baking, and the tank was ready for the first application of "elbow grease". Willing hands, stiff brushes and kitchen soap powder removed the last of the black algae spots, about the size of 25 cent pieces that seemed to have become a very part of the walls and floor.

Disinfection was the next operation. The walls and floors were mopped with generous solutions of "H.T.H." (This is a Matthieson Chemical Product, claiming 70% available chlorine, a true double calcium hypochlorite, $Ca(OCl)_2$. The product is easily soluble in water, and is used for this purpose in concentrations of an ounce per gallon. As the outlet valve is at the very end of a long drain that leads from the pool, that drain is really part of the pool and has to be carefully disinfected with higher chlorine concentrations. Sun-bleaching for days helped the work of chlorination. A final application of chlorine was made, and the last of the preparatory work began: filling the pool.

The water gushed in at a pH value of 6.8 or less. Now health practice allows the pH range: 7.2 to 8.6. If the chlorination was to be done with the calcium vehicle, "H.T.H.", for example, or chloride of lime, (ClCaOCl), there would not be much profit in using soda ash ($Na_2CO_3$) for raising the pH value, since a precipitate, calcium carbonate ($CaCO_3$), would be formed. About 12 lb. of high percentage caustic soda (NaOH) were required to raise the pH value one point. That was over six times the theoretical amount.

But the alkalinity of the water is not the only factor that health practice demands. Chlorination is necessary. Literature mentions two types of chlorine demand:

1) to satisfy the initial chlorine demand of the system.

2) to maintain an excess over this demand by 0.2 to 0.5 parts per million (p.p.m.) available chlorine. These microscopic or astronomical concentration values are not as bad as they look to the laboratory chemist at first sight. The conversion: 1 p.p.m. = 1 mg./L puts the units on a familiar basis.

The initial chlorine demand of the system in an outdoor pool is not the relatively constant factor that one might expect from an indoor pool. Out-of-doors, too many variable conditions are encountered. Nor was the expense of chlorination as low as one would expect even for a pool that was to be filled but very few times in the season, and rely on chemical control to reduce the number of refillings. For water is expensive too, especially in 70,000 gallon quantities. In our outdoor pool, these two factors merged to create a single problem. H.T.H. wholesales at circa forty cents per pound. Theory required about six ounces per day for chlorination. But practice showed that chlorination for all factors might well break a second dollar each day.

Copper sulfate ($CuSO_4$) is generally a good and cheap algicide, but it fails at full bacterial protection. Moreover, at pH values higher than pH 7, its continued use is impracticable because of the formation of a CuO precipitate, whose copper content is practically unavailable. Daily treatment, rain or shine, with some chemical is necessary, so that the algae and infusion organisms of an outdoor system cannot get too much of a start.

Literature further distinguishes between:

1) Continuous treatment. For example, when chlorine is introduced into the system from a tank of the gas or when water is circulated through a container of a chlorine carrier; and

2) Intermittent treatment. For example, when the chlorine carrier is added directly to the pool water from time to time.

With no equipment at hand, our apparent choice fell, of necessity, on the second type of treatment. Tests, made from one-half to three-quarters of an hour from the time of treatment, showed at times, no free chlorine,—at times concentrations of less than 2 p.p.m. chlorine.

Some kind of continuous treatment was necessary. The use of chloride of lime of high chlorine content (35%) seems to be the solution of the problem. This is not expensive. On the basis of the same percentage available chlorine, it costs at the present about one-fifth as much as true calcium hypochlorite. It is disagreeable to handle, but for one who must use it daily, a technique is soon developed. Its best quality is the fact that it dissolves very slowly and smoothly with the evolution of chlorine gas. This advantage, coupled with the economy of it, makes it eminently suited for the pool described.

A small pail of about six inch diameter and seven inch height was perforated, bottom and cover, with a triangular laboratory file (quarter inch sides), charged with chloride of lime each day, and suspended by a cord from the diving board.

The metal pail corrodes but slowly. Replacements are made by requisitioning used lard pots from the kitchen. The cover is necessary. Otherwise some of the particles of the chemical might be floated to the surface of the pool on gas or air bubbles. Suspension by a cord from the diving board is a help. Thus it is disturbed from time to time and some circulation of the contents into the pool is assured. It is safe enough, because it is placed where it is almost inaccessible to bathers. If it is drawn from the water two or three times in succession to drain the chloride of lime suspension out into the water, every half hour by one of the bathers while the pool is in use, then adequate bathers' protection is assured as tests will show. By this method, it is almost impossible to exceed the upper health limit of available chlorine concentration (0.5 p.p.m.); and some chlorine is available to the pool when idle to check the growth of bacteria and algae.

Such then is the chemical protection of such an outdoor pool. This must be supplemented by skimming the surface of pollen and blossom, and sweeping the floor of waterlogged flotsam, twigs and debris. The overflow outlets were sandbagged. Water was then run into the pool to bring it to a higher level. The surface could then be skimmed with a gauze net. The collection was brought to one of the gutters and floated off. This method was not wholly satisfactory. It was perhaps the best that could be devised under the circumstances. Windy days always helped in concentrating flotsam into one of the corners of the pool.

A second adjunct to the chemical treatment of an outdoor pool is the periodic removal of sediment from the floor. This is probably composed of precipitated chemicals and dust, of partially decomposed organic matter that has been blown onto the surface, escaped the skimming process, waterlogged and sunk. The treatment that follows gave likewise only partial satisfaction. It consists in dragging a heavy object along the floor of the pool from shallower to deeper end. The screen of an abandoned sand sieve was used. A cloud of sediment develops through a foot or two in the water above the floor, and the sediment is gradually worked down to the outlet. The outlet valve is opened for a moment or two and the bulk of the material is washed out. After opening the valve, heavier chlorine concentration is again established in the drain pipe, by sinking a few lumps of chloride of lime into the drain. The "log" of other years indicates the success of the following method. Instead of dragging, the floor was scruffed vigorously by bathers with the back of a rake. The sediment was swept to the drain in this fashion and removed by opening the valve for a time.

There were a few other points in the program of 1940 that we did not have time to carry out. The first is that of water clarification. We did not like the prospect of working with alum, because of the

slippery sediment we expected it to produce. The problems seem to have been solved with fair satisfaction in the choice of the chlorine vehicle made: chloride of lime. It is probably a fact that the hydrated lime ($Ca(OH)_2$ decomposition product from this complex dragged down the suspended matter that found its way into the pool. This seemed to be only a partial solution to this problem, for, although one could invariably see the bottom when the sediment was not stirred up, still there was always a whitish tint observable in the water, due probably to suspended chemicals.

That chemical was likely excess hydrated lime. And the observation provides a "takeoff" for another step in the uncompleted program: water softening. Literature indicates that fused briquettes of soda-ash ($Na_2CO_3$) provides an excellent water-softener. A briquette or two may be wrapped in a white cloth bag and suspended in the pool by a cord. The briquette should dissolve at a slow and even rate. The beauty of this treatment should be that on opening the bag after the chemical is dissolved, a calcium etc. precipitate is found there and is easily discarded. These briquettes are economical enough and compare in price very favorably on the basis of active material with commercial 58% soda-ash which contains so much inactive water of hydration. If the pool were so treated, the problem of pH control, clarification and sediment might have to be solved anew. And water-softening is probably an unnecessary refinement for an outdoor pool.

The results in health protection are difficult to estimate. Not a complaint of "athlete's foot" was heard. The pool environs were carefully disinfected at definite intervals. Regimentation and regulations for bathers were reduced to a minimum. Some of the bathers seemed to develop colds during the early season. This could probably be ascribed among other things to hay fever from the pollen that for ten days at least was very difficult to remove from the surface.

For making the tests a LaMotte combination swimming pool comparator was used. Reagent refills provided the best confidence in chemical results while carrying on the work where neither laboratory equipment nor much literature was available. Sampling and testing were performed with quantitative technique. Chlorine tests were disappointing at times. But when the sample was collected in a clean glass container, not exposed to light too long, and tested as soon as possible at the poolside, satisfactory results were obtained: chlorine: 0.2 to 0.5 p.p.m., pH: 7.7. Sometimes it took some minutes for the orthotolidine test to develop color.

On the whole the work was as enjoyable as the fruits of it; and as the reader may agree the experience was highly instructive.

# MATHEMATICS

## A SELECTED BIBLIOGRAPHY ON THE FOUNDATIONS OF MATHEMATICS

Rev. Everett H. Larguier, S.J.

While the following bibliography contains technical research as well as critical and expository material, no attempt at completeness on any point has been made. Undoubtedly this will not prove satisfactory to many who will feel that numerous worthy items have been omitted. But the only adequate method of pleasing everyone would be a complete listing of all items related to the problem—a project which, however commendable it might be in itself, is altogether out of the question here. Consequently the compiler must ask the reader's indulgence on this score.

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# *From the Editor's Desk*

THE CHICAGO CONVENTION is a thing of the past, but some of the echoes still resound. The BULLETIN intends to publish a brochure containing the excellent historical papers which were read at the convention as a part of the four hundredth anniversary celebration of the Society. The brochure will appear shortly after the beginning of the year and will be sent to the members of the Association.

"NO NEWS IS GOOD NEWS" is not verity where News Items are concerned. Everyone is interested in knowing what everyone else is doing and it is through the BULLETIN that the word is spread. Incidentally, we feel that it would be very much for the common good if we let each other know what graduate fellowships, instructorships, etc. are available for the coming year in the science departments of the various colleges and universities. If the response warrants it, we will publish in the March issue of the BULLETIN a list of the available fellowships in Jesuit Colleges.

BECAUSE OF THE LARGE NUMBER of abstracts in the last issue, the list of the members of the Association was held over and is published in this number. We have not a complete list of the new members admitted this year, so if there are any new members whose names are not included in the enumeration, we would appreciate it if they would notify us so that we can rectify the omission.

TO GIVE CREDIT WHERE CREDIT IS DUE—the cover design of the BULLETIN comes from the hand of Mr. Joseph Connors, S.J., of Weston College, and to him we wish to express our gratitude. And while acknowledgments are being made, we wish also to thank Sullivan Brothers, of Lowell, Massachusetts, for the new format. And last, but by no means least, a word for those who are keeping up the high standards of the BULLETIN. You will find their names at the beginning of their articles.

# NEWS ITEMS

## BOSTON COLLEGE

### Course in Geo-Navigation

A course in Geo-Navigation, open to all classes except Freshman, is being offered this year by the college. The course is to cover 10 periods of 4 hours each on 10 successive Saturdays and embraces among other subjects: Familiarization with charts and publications; Mercator chart; Sextant errors and zone time; Instruments; Compass errors; Compass compensation; Sailings, Tides and Lights; Fog Aids; Radio Aids; Navigator's general piloting duties. The course will be conducted by Captain Charles C. Soule, U.S.N. (Ret.). Captain Soule is a graduate of the U.S. Naval Academy at Annapolis, and subsequently taught there for six years. He is the author of many articles on subjects of Naval and Marine interest.

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### Chemistry Department

Doctor John K. Rouleau, Professor of Physical Chemistry, has left the department for a year's active duty as a Captain in the Ordnance Department of the Army. At present he is stationed in Joliet, Illinois.

A semester course in Industrial Chemistry, an elective for Senior chemistry students, will be offered during the second semester.

Father McGuinn has been made a member of the Membership Committee of the Northeastern Section of the American Chemical Society.

There are four fellowships, carrying a stipend of $300, tuition exemption, etc., open in the department for 1941-1942.

The student publication, The Crystal, received mention in the Editor's column of the October issue of the Journal of Chemical Education.

A course in Semi-micro Quantitative Organic Analysis is being conducted for graduate students. Father McGuinn is teaching this course.

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### Physics Department

We have been able this year to evaluate the courses given during the last three years in the B.S. in Physics Course. In Sophomore the eight semester credit course in Physical Optics and Thermodynamics has been arranged to use the Calculus given in this year. In Junior the eight semester course in Mechanics and Optics has been given

along with Differential Equations. In Senior the eight semester course in Electricity has been arranged to use the Vector Analysis and Partial Differential Equations. In all these courses the laboratory work is so different from the general course that the students find it difficult to perform the experiments without a "cook book" explanation. In the Junior year the students must take a four semester course in the Theory of Measurements and Mechanical Drawing. In Senior they must take a four semester course in Modern Physics and Philosophy. In this way a graduate has thirty two credits in Physics beyond the General Course in Freshman.

Fr. McKone, who is attending the Graduate Courses this year, is doing his thesis work on the measurement of the velocity of sound. The method makes use of a large iron cylinder with earphones fitted into the reflecting walls of the cylinder. The frequency is varied by means of a Frequency-Beat Oscillator, and the maximum amplitude points are detected by a Cathode Ray Oscillograph. The iron cylinder is capable of sustaining high pressures and it can be easily evacuated in order to put in various gases. Air has been used up to the present and very accurate results have been obtained. It is planned now to study other gases at varying temperatures and densities.

The Civil Pilot Training is continuing this year, and a course in Navigation for the U.S. Navy is given on Saturdays. Defence work in Radio Communication is given in the Radio Club.

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## CANISIUS COLLEGE

### Department of Biology

Father Frisch spent the months of July and August at the Marine Biological Laboratory at Woods Hole, Cape Cod, Mass. Two of his students, Richard W. Egan and F. Donal O'Brien were with him in the capacity of research assistants, and gave him valuable technical aid. The problem they worked on is a continuation of Father Frisch's previous studies of the physiology of the protozoan, Paramecium: "The effect of continuous culture, for three years, in various concentrations of sea water, on the physiology of Paramecium." The student assistants paid their own expenses of fare, board and lodging.

At the summer meeting of the Trustees of the Corporation of the Marine Biological Laboratory Father Frisch was elected a member of the Corporation. He is the only Jesuit member, and, as far as he can learn, the first.

Canisius is now listed in the catalogue of the Marine Biological Laboratory as one of the subscribing and cooperating institutions, the only Jesuit college listed.

Two years ago the department introduced a new policy in the selection of student laboratory instructors. As formerly, the student receives free tuition during his Junior and Senior years. The new requirement is that he must, at his own expense, enroll in the Inver-

tebrate Course at the Marine Biological Laboratory. The expense amounts to over $200.00. Thus far we have had no difficulty in getting applicants for the position of instructor. Mr. Richard W. Egan, who assisted Fr. Frisch this summer, was the first student to go to Woods Hole; last summer Mr. Wallace Hildebrandt took the course. Both of these boys are enthusiastic about Woods Hole and both are engaged in research work, as a result of the stimulus and inspiration they received while at the Marine Biological Laboratory.

The Mendel Club recently became a charter member of the newly organized Council of Scientific Societies of Western New York. The Council is sponsoring a Science Symposium at the Buffalo Museum of Natural History, at which Mr. Egan and Mr. O'Brien, members of the Mendel Club, are exhibiting a collection of over 100 species of marine invertebrates, which they collected in the environs of Woods Hole and the Elizabethan Islands. Mr. Wallace Hildebrandt, also of the Mendel Club, is illustrating the exhibit with detailed color drawings of the anatomy of many of the specimens. In addition Mr. Egan is showing color movies of the Marine Laboratory and of the locations where the specimens were collected.

The Mendel Club, jointly with the Strohaver Club, conducted a very successful annual dance, each club netting over $200.00. The Mendel Club is setting aside its share of the proceeds as a nucleus for establishing a scholarship table at the Marine Biological Laboratory.

Father Frisch published an article, entitled "Did the Peckhams witness the invention of a tool by Ammophila urnaria?" in the September issue of the American Midland Naturalist, vol. 24, no. 2, pp. 345-350.

Father Flood has returned to the department to teach an extension course in Anatomy and Physiology and the Junior Premedical courses in Embryology and Histology. At present he is also engaged in improving the laboratory material for these courses by the preparation and purchase of additional and supplementary slides. He is also searching the biological journals for work in Comparative Anatomy, Embryology and Histology suitable for study and verification by the biology majors.

The Lecture Program of the Mendel Club for the Scholastic Year Is as Follows:
1940

October 7—*"Ways and Means."*

October 21—*"The Use of Insulin in The Treatment of Schizophrenia"*
Charles F. Cipolla, R.N.
Student Biology Laboratory Instructor, Canisius College

November 4—*"The Development of Neurological Surgery."*
Wallace B. Hamby, B.A., B.S. (Med.) M.D., F.A.C.S.
Associate in Neurology, Instructor in Surgery,
University of Buffalo, Medical School

November 18—*"Public Health"*

Francis A. Fronczak, A.B., A.M.M.D., Dr. P.H.

Health Commissioner of Buffalo

December 2—*"Controlling Syphilis", Illustrated.*

Lupo DeMello, M.D.

Medical Consultant, New York State Department of Health, On Syphilis Control

December 16—*To be Announced.*

December 23—*Alumni Banquet.*

1941

January 13—*"Report on the A.A.A.S Meetings, Zoological, Phil., Penn. Illustrated.*

Richard W. Egan

Student Biology Laboratory Instructor and

F. Donal O'Brien

Canisius College

February 3—*"Ways and Means."*

February 17—*"Dental Education."*

Russel W. Groh, D.D.S.

Associate Dean, University of Buffalo, School of Dentistry

March 3—*"United States Navy, Medical Corps."*

Lieut. Comm. Norman J. Haverly, M.D., M.C., U.S.N.

March 24—*"Orthodontics." Illustrated.*

Harold E. Sippel, D.D.S.

Associate Visiting Orthodontist, Meyer Memorial Hospital

April 7—*To be Announced.*

April 21—*"Ways and Means."*

May 12—*Annual Banquet.*

## HOLY CROSS COLLEGE
### Chemistry Department

Glass Blowing Seminar.

Formal lectures and demonstrations by Rev. Joseph J. Sullivan, S.J. Topics: Laboratory glass-ware, kinds and properties. Cleaning, storing. Devitrification. Glass-worker's tools. Simple operations of cutting, rotating glass in flame, bending, flaring, constricting. Various seals. Repairs. Construction of apparatus. Sealing metals into glass. Platinum welding. Student practice is ad lib. Student papers on study of Glass is part of the Program.

Diffusion Experiment.

A two foot tube, containing enough $CuSO_4.5H_2O$ to form a saturated solution, was carefully filled with distilled water and sealed with a vaselined ground glass top. This was placed in one of our exhibit cases on November 6, 1940, and the attention of the students was called to this experiment. In two weeks' time the blue line has hardly risen two inches.

Seminars, 1940-1941.

Abbé Haüy
Mr. Joseph H. Carpentier, B.S., (M.S.,'41) October 28, 1940

Passivity in Metals
Mr. Peter F. Della Luna, B.S., (M.S.,'41) November 4, 1940

The Determination of the Dissociation Constant of Acetic Acid
Mr. Charles O. Herman, B.S., (M.S.,'41) November 18, 1940

Resonance in Organic Compounds
Mr. Theodore W. Sarge, B.S., (M.S.,'41) November 25, 1940

Fragments of Atoms
Mr. Raymond J. Twining, B.S., (M.S.,'41) December 9, 1940

The Cis-Trans Isomerization of Methyl Cinnamate in the Gaseous Phase
Mr. Jeremiah J. Twoomey, B.S., (M.S.,'41) December 16, 1940

Recent Advances in the Analysis of the Tin Group
Mr. William H. Bromley, (B.S.,'41) January 13, 1941

Wetting Agents
Mr. John G. Byrne, (B.S.,'41) January 20, 1941

Chromatographic Adsorption
Mr. Leonard C. Clossey, (B.S.,'41) February 10, 1941

Phase Diagrams—Ternary Systems
Mr. William J. Fox, (B.S.,'41) February 17, 1941

Identification of Sugars
Mr. James F. Little, (B.S.,'41) February 24, 1941

Synthetic Rubber
Mr. Cornelius B. Murphy, (B.S.,'41) March 3, 1941

Organic Reagents in Analytical Chemistry
Mr. Robert H. Avery, (A.B.,'41) March 10, 1941

The Salt Effect
Mr. Robert I. O'Herron, (B.S.,'41) March 24, 1941

Chelate Compounds
Mr. John E. Shea, Jr., (B.S.,'41) March 31, 1941

Gels and Emulsions
Mr. Anthony N. Sinelitico, (B.S.,'41) April 7, 1941

Spot Tests in Analysis
Mr. Frederick J. Storm, (B.S.,'41) April 21, 1941

Ionic Reactions in Organic Chemistry
Mr. Harry W. Woodin, Jr., (B.S.,'41) April 28, 1941

Fr. Sullivan, Chairman of Chemistry Department was elected Vice President of the Worcester Chemists' Club at the last meeting in June.

On August 16, 1940, Assistant Professor Edwin T. Mitchell gave a talk at the Summer Conference ot the N. E. A. C. T. held at the University of Maine. His topic *Some New Lecture Experiments* was highly commended by those present.

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## Department of Physics and Mathematics

Rev. Joseph T. O'Callahan, S.J., has been appointed Junior Lieutenant in the United States Navy (Reserve).

Mr. John K. Chenis, assistant professor of mathematics, resigned his position at Holy Cross College on October 31, 1940 to accept a position in the Treasury Department of the United States Government. Mr. Chenis joined the Physics Department two weeks after he received his B.S. degree in Physics at Holy Cross College in June, 1930. He received his M.A. degree in Mathematics from Boston College Graduate School last June.

Dr. Alfred Basch lectured at the Worcester Natural History Society on October 29th and November 5th. He spoke on "Celestial Mechanics".

Rev. Thomas H. Quigley, S.J. has been elected a Fellow in the American Association for the Advancement of Science.

Mr. Donald F. Grady, S.J., in addition to his work in the Physics' laboratory, is now acting librarian for the new reference library of the Department of Physics and Mathematics.

The ten students in the quota assigned to Holy Cross College by the Civil Aeronautics Authority have successfully passed their first important test and were recently awarded their solo license at the North Grafton Airport.

The Holy Cross Scientific Society, now composed in large part of pre-medical students, will devote a considerable portion of the coming year to a thorough discussion of the microscope. The recent ap-

pearance of the Electron Microscope has made it imperative for our future doctors to have a good grasp of the physical principles underlying modern microscopy. De Broglie's brilliant conception of the wave characteristics of matter has provided the future doctor with a microscope of remarkable resolving power.

The Physics Seminar, limited to the advanced students in Physics and Mathematics, will be continued this year under the direction of Fr. Quigley, S.J. The topic for discussion will be "X-Ray Spectra".

The Mathematical Seminar opens this year under the direction of Dr. Basch. The topic for discussion will be "Potential Theory".

Mr. Thomas B. Dowd '41 will devote a considerable portion of the coming year to a determination of the Mechanical Equivalent of Heat with Gaertner's modification of the Rowland apparatus.

Mr. John J. Murphy '41 is to determine the acceleration of gravity with the Kater pendulum and the Leeds and Northrup Synchronous Timer. He is to work in the old seismological laboratory under the O'Kane entrance. This site is well adapted for the problem since the temperature is reasonably constant there and the height above sea-level is known.

Mr. Philip M. Reidy '41 will design and construct a receiver for Radio-frequency modulated broadcasts. We are again fortunate in having two stations transmitting this broadcast in the environs of Worcester.

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## LOYOLA COLLEGE, BALTIMORE, MARYLAND

### Chemistry Department

There are eighty students in the class of semi-micro qualitative inorganic analysis. Each student is supplied with a chem-kit of fifty-two liquid reagents and forty-six solid reagents. The text that is used is: Semi-micro Qualitative Analysis, by Evans, Garrett and Quill.

Every analytical balance in the entire chemistry department is equipped with a cold fluorescent light; this improves the accuracy of weighing in the quantitative course.

New sectional book-cases were added to the chemistry library; there are now over 1300 volumes in the library.

A new laboratory for physical chemistry was recently built in the department.

# Membership of Association

**1940 – 1941**

GENERAL OFFICERS

*President*

Rev. John A. Tobin, Boston College, Chestnut Hill, Mass.

*Secretary*

Mr. John J. Blandin, S.J., Loyola College, Baltimore, Md.

*Executive Council*

Very Rev. James P. Sweeney, S.J., 501 E. Fordham Road, New York, N. Y.
Very Rev. James H. Dolan, S.J., 300 Newbury St., Boston, Mass.
Rev. James L. Harley, S.J., Gonzaga High School, Washington, D. C.
Rev. Joseph M. Kelley, S.J., Loyola High School, Baltimore, Md.
Rev. Albert F. McGuinn, S.J., Boston College, Chestnut Hill, Mass.
Rev. Joseph T. O'Callahan, S.J., Holy Cross College, Worcester, Mass.
Mr. John J. Blandin, S.J., Loyola College, Baltimore, Md.

*Editors of the Bulletin*

Editor in-Chief—Rev. Anthony G. Carroll, S.J.
Boston College, Chestnut Hill, Mass.

Associate Editors—Rev. James L. Harley, S.J.
Rev. Joseph M. Kelley, S.J.
Rev. Albert F. McGuinn, S.J.
Rev. Joseph T. O'Callahan, S.J.

*Correspondents*

Chicago Province—Rev. Victor C. Stechschulte, S.J.,
Xavier University, Cincinnati Ohio.

Missouri Province—Rev. Paul L. Carroll, S.J.,
Creighton University, Omaha, Neb.

New Orleans Province—Rev. George A. Francis, S.J.,
Loyola University, New Orleans, La.

California Province—Carroll M. O'Sullivan, S.J.,
Alma College, Alma, Calif.

Oregon Province—Rev. Leo J. Yeats, S.J.,
Gonzaga University, Spokane, Wash.

Canadian Province—Rev. Eric O'Connor, S.J.,
45 Cooper St., Boston, Mass.

Note: The figures at the end of each entry indicate the year the member was admitted to the Association.

## BIOLOGY SECTION

### *Officers*

Chairman—Rev. James L. Harley, Gonzaga High School.
Secretary—Joseph E. Schuh, Fordham University.

### *Members*

Anable, Rev. Edmund A., 1921, Fordham University.
Anable, Richard J., 1939, Canisius High School.
Assmuth, Rev. Joseph, 1930, Fordham University.
Avery, Rev. Henry C., 1923, Ateneo de Manila.
Bauer, Mark, 1935, Gonzaga High School.
Berger, Rev. Charles A., 1926, Woodstock College.
Brown, J. Robert, 1934, Woodstock College.
Busam, Rev. Joseph F., 1925, Holy Cross College.
Callahan, Rev. Edward A., 1932, Holy Trinity Church.
Carroll, Philip, 1937, Woodstock College.
Coniff, Rev. Arthur A., 1923, Georgetown University.
Cronin, Thomas C., 1935, Woodstock College.
Deeley, James J., 1937, Holy Cross College.
Didusch, Rev. Joseph S., 1922, Loyola College.
Dore, Rev. Francis J., 1922, Boston College.
Dougherty, John J., 1937, Woodstock College.
Dubois, Rev. Edwin C., 1924, Boston College.
Ewing, Rev. J. Franklin, 1933, University of Paris.
Fay, John G., 1939, Loyola College.
Flood, Rev. Francis X., 1932, Auriesville, N. Y.
Freatman, Rev. Harold L., 1924, St. Joseph's College.
Frisch, Rev. John A., 1925, Canisius College.
Gerry, Stanislaus T., 1939, Boston College.
Gookin, Rev. Vincent A., 1923, Baghdad, Iraq.
Harley, Rev. James L., 1927, Gonzaga High School.
Hennessey, Gerald J., 1934, Weston College.
Keegan, Rev. Joseph G., 1930, University of London.
Kirchgessner, Rev. George J., Cagayan, Oriental Misiamis, P. I.
Kleff, L. C., 1939, St. Joseph's College.
Lawlor, George, 1939, St. Louis University.
Lynch, Rev. Joseph P., 1932, Auriesville, N. Y.
MacCormack, Rev. Anthony I., 1925, Weston College.
McCauley, Rev. David V., 1923, Georgetown University.
Murray, Joseph W., 1934, Woodstock College.
O'Brien, John J., 1934, Woodstock College.

Pfeiffer, Rev. Harold A., 1931, Xavier High School.
Reardon, Rev. Francis X., 1928, Ateneo de Manila.
Schuh, Joseph E., 1939, Fordham University.
Shaffrey, Rev. Clarence E., 1923, St. Joseph's College.
Smith, Rev. Thomas N.
Stoffel, Joseph L., 1933, Woodstock College.
Walsh, Michael P., 1935, Weston College.
Walter, Rev. William G., 1930, St. Peter's High School.
Wilkie, Rev. Francis X., 1934, Cranwell Hall.
Zegers, Richard T., 1934, Woodstock College.

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## CHEMISTRY SECTION

*Officers*

Chairman—Rev. Albert F. McGuinn, Boston College.

*Members*

Ahern, Rev. Michael J., 1922, Weston College.
Blandin, John J., 1939, Loyola College.
Blatchford, Rev. John A., 1923, Winchester Park.
Brady, John J., 1938, Woodstock College.
Barrett, Joseph L., 1937, Weston College.
Brophy, Rev. Thomas A., 1932, Auriesville, N. Y.
Brosnan, Rev. John A., 1923, Woodstock College.
Brown, Rev. Thomas J., 1932, Canisius College.
Butler, Rev. Thomas B., 1922, Cranwell Hall.
Carroll, Rev. Anthony G., 1929, Boston College.
Cawley, Joseph A., 1938, Woodstock College.
Cheney, Edmund K., 1935, Weston College.
Cummings, Rev. William V., 1932, ~~Auriesville, N. Y.~~
Dailey, Francis J., 1938, Weston College.
Doino, Rev. Francis D., 1930, Ateneo de Manila.
Fickers, Rev. Bernard A., 1933, Holy Cross College.
Gisel, Rev. Eugene, 1925, Ateneo de Manila.
Guay, Leo J., 1935, Weston College.
Haggerty, Gerard A., 1934, Woodstock College.
Hauber, Rev. Edward S., 1929, Fordham University.
Hohman, Rev. Arthur J., 1922, St. Peter's College.
Hufnagle, Rev. Alvin A., 1933, ~~Woodstock College~~.
Hutchinson, Rev. Gerald F., 1933, Weston College.
Kelleher, Rev. William L., 1932, Provincial's Residence.
Landrey, Rev. Gerald M., 1930, Cranwell Academy.
Martus, Rev. Joseph A., 1934, Weston College.
McCawley, Edward G., 1934, Woodstock College.
McGuinn, Rev. Albert F., 1932, Boston College.

Molloy, Rev. Joseph J., 1929, St. Joseph's College.
Moynihan, Rev. Joseph C., 1930, 45 Cooper St., Boston, Mass.
Muenzen, Rev. Joseph B., 1923, Fordham University.
O'Byrne, Rev. Francis M., 1934, St. Andrew-on-Hudson.
Pallace, James J., 1934, Woodstock College.
Power, Rev. Francis W., 1924, Fordham University.
Quevado, Anthony J., 1933, Woodstock College.
Schmitt, Rev. Richard B., 1921, Loyola College.
Sullivan, Rev. Joseph J., 1923, Holy Cross College.
Thiry, James H., 1935, Woodstock College.

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## MATHEMATICS SECTION

### *Officers*

Chairman—Rev. Joseph T. O'Callahan, 300 Newbury St., Boston
Secretary—John P. Murray, Boston College.

### *Members*

Benedetto, Francis A., 1939, Fordham University (New Orleans Prov.)
Ball, Harry W., 1937, Weston College.
Barry, Rev. Thomas D., 1926, Weston College.
Berry, Rev. Edward B., 1922, Fordham University.
Caulfield, John F., 1939, Boston College.
Cohalan, Joseph F., 1934, Woodstock College.
Connolly, Rev. James K., 1933, Weston College.
Crowley, Joseph P., 1939, Cranwell Academy.
Depperman, Rev. Charles E., 1923, Manila Observatory.
Dineen, Edward H., 1938, Georgetown University.
Donohoe Francis J., 1937, Weston College.
Donohoe, Joseph J., 1934, Weston College.
Doucette, Rev. Bernard F., 1925, Manila Observatory.
Duross, Rev. Thomas A., 1932, Xavier High School.
Dooley, Rev. Joseph C., 1934, Weston College.
Dutram, Rev. Francis B., 1935, Boston College.
Eiardi, Anthony J., 1935, Weston College.
George, Rev. Severin E., Woodstock College.
Gough, Raymond, 1938, Xavier High School.
Greene, Merrill F., 1939, Boston College.
Hennessey, James J., 1933, Woodstock College.
Judah, Rev. Sidney J., 1934, Jamaica, B. W. I.
Kelley, Rev. Joseph M., 1922, Loyola High School.
Love, Rev. Thomas J., 1923, St. Joseph's College.
MacDonnell, Robert F., 1937, Weston College.
McCarthy, John J., 1938, Boston College.
McCauley, Charles E., 1934, Woodstock College.

McCormick, Rev. James T., 1923, St. Robert's Hall.
McDevitt, Rev. Edward L., 1933, Woodstock College.
McGrath, Rev. Philip H., 1932, St. Peter's College.
McNally, Rev. Paul A., 1923, Georgetown University.
Merrick, Rev. Joseph P., 1923, Baghdad, Iraq.
Morgan, Rev. Carol H., 1933, St. Robert's Hall.
Mulchay, John J., 1938, Boston College High School.
Murray, Rev. Joseph P., 1928, Boston College High School.
Murray, John P., 1939, Boston College.
Neuner, Charles M., 1938, Georgetown University.
Nuttall, Rev. Edmund J., 1925, Manila Observatory.
O'Brien, Kevin J., 1933, Woodstock College.
O'Callahan, Rev. Joseph T., 1929, Holy Cross College.
O'Donnell, Rev. George A., 1923, Boston College.
Phillips, Rev. Edward C., 1922, Woodstock College.
Quigley, Rev. Thomas H., 1925, Holy Cross College.
Repetti, Rev. William C., 1922, Manila Observatory.
Rocks, Rev. Thomas J., 1937, Woodstock College.
Rooney, Rev. Albert T., 1933, Woodstock College.
Schweder, William H., 1933, Woodstock College.
Smith, Rev. John P., 1923, Loyola College High School.
Smith, Rev. Thomas J., 1925, Weston College.
Sheehan, Rev. William D., 1928, Baghdad, Iraq.
Sohon, Rev. Frederick W., 1924, Georgetown University.
Sweeney, Rev. Joseph J., 1930, Boston College High School.
Wessling, Rev. Henry J., 1923, Boston College High School.

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## THE PHILOSOPHY OF SCIENCE

Ahern, Rev. Michael J., 1922, Weston College.
Cotter, Rev. Anthony C., 1936, Weston College.
Coyne, Rev. Francis J., 1926, Boston College.
Dooley, Rev. Edward, 1936, Canisius College.
Fiardi, Anthony J., 1935, Weston College.
Glose, Rev. Joseph C., 1930, Woodstock College.
Kelly, Rev. Joseph P., 1931, Weston College.
Lynch, Rev. J. Joseph, 1925, Fordham University.
Murphy, Rev. John J., 1936, Boston College.
O'Beirne, Rev. Stephen, 1935, Woodstock College.
O'Callahan, Rev. Joseph T., 1929, Holy Cross College.
O'Conor, Rev. John S., 1928, Woodstock College.
Ring, James W., 1935, Weston College.
Schoberg, Rev. Ferdinand W., 1936, Loyola College.
Sohon, Rev. Frederick W., 1924, Georgetown University.
Tobin, Rev. John A., 1923, Boston College.
Toohey, Rev. John J., 1934, Georgetown University.

## PHYSICS SECTION

### *Officers*

Chairman—Rev. Joseph M. Kelley, Loyola High School.
Secretary—Edward R. Powers, Georgetown University.

### *Members*

Benedetto, Francis A., 1939, Fordham University (New Orleans Prov.)
Berry, Rev. Edward B., 1922, Fordham University.
Brock, Rev. Henry M., 1922, St. Robert's Hall.
Burns, William F., 1935, Weston College.
Caulfield, John F., 1939, Boston College.
Cohalan, Joseph F., 1934, Woodstock College.
Connelly, Rev. James K., 1933, Weston College.
Crowley, Joseph P., 1939, Cranwell Hall.
Daley, Rev. Joseph J., 1930, Manresa Institute, Keyser Island.
Delaney, Rev. John P., 1923, Loyola College.
Depperman, Rev. Charles E., 1923, Manila Observatory.
Devlin, James J., 1934, Weston College.
Doherty, Rev. Joseph G., 1930, Cambridge University.
Dutram, Rev. Francis B., 1931, St. George's College.
Fitzgerald, John F., 1935, Weston College.
Frohnhoefer, Rev. Frederick R., 1926, Xavier High School.
George, Rev. Severin, 1933, Woodstock College.
Greene, Merrill F., 1939, Boston College.
Guichetau, Rev. Armand J., 1932, ~~Auriesville, N. Y.~~
Hearn, Rev. Joseph R., 1925, ~~Georgetown University~~.
Hennessey, James J., 1933, Woodstock College.
Heyden, Rev. Francis J., 1931, 300 Newbury St., Boston, Mass.
Kelley, Rev. Joseph M., 1922, Loyola High School.
Kirsch, Simon C., 1937, Woodstock College.
Kolkmeyer, Rev. Emeran J., 1922, ~~Canisius College~~.
Langguth, Laurence C., 1935, Weston College.
Linehan, Rev. Daniel, 1931, St. Robert's Hall.
Love, Rev. Thomas J., 1923, St. Joseph's College.
Lynch, Rev. J. Joseph, 1925, Fordham University.
MacDonnell, Robert F., 1937, Weston College.
McAree, Rev. Joseph F., 1922, Brooklyn Prep.
McCarthy, John J., 1938, Boston College.
McDevitt, Rev. Edward L., 1933, ~~Woodstock College~~.
McGrath, Rev. P. H., 1932, St. Peter's College.
McKone, Rev. Peter J., 1931, Boston College.
McNally, Rev. Herbert P., 1922, ~~Gonzaga High School~~.
Merrick, Rev. Joseph P., 1923, Baghdad, Iraq.
Miller, Rev. Walter J., 1931, 300 Newbury St., Boston, Mass.
Morgan, Rev. Carol H., 1933, St. Robert's Hall.
Murray, Rev. Joseph L., 1928, Boston College High School.

Murray, John P., 1939, Boston College.
Nuttall, Rev. Edmund J., 1925, Manila Observatory.
O'Brien, Kevin J., 1933, Woodstock College.
O'Callahan, Rev. Joseph T., 1929, Holy Cross College.
O'Connor, Rev. Eric, 1936, Weston College.
O'Conor, Rev. John S., 1923, Woodstock College.
Phalen, Robert P., 1935, Weston College.
Phillips, Rev. Edward C., 1922, Woodstock College.
Quigley, Rev. Thomas H., 1925, Holy Cross College.
Reardon, Rev. Timothy P., 1935, Woodstock College.
Ring, James W., 1935, Weston College.
Schweder, William H., 1933, Woodstock College.
Sheehan, Rev. William H., 1933, Baghdad, Iraq.
Smith, Rev. John P., 1923, Loyola College High School.
Smith, Rev. Thomas J., 1925, Weston College.
Thoman, A. Robert, 1933, Woodstock College.
Tobin, Rev. John A., 1923, Boston College.
Walsh, Rev. Lincoln J., 1931, Canisius High School.
Welch, Rev. Leo W., 1930, Manila Observatory.
Zegers, Theodore A., 1934, Woodstock College.

N. B. IF THERE ARE ANY ERRORS OR OMISSIONS IN THIS LIST PLEASE NOTIFY THE EDITOR.

# ANNUAL MEETING

OF THE

# NATIONAL ASSOCIATION

OF

# JESUIT SCIENTISTS

**Monday, December 30, 1940**

at 4:00 P. M.

**St. Joseph's High School**

18th and Thompson Sts. Philadelphia, Pa.

American Association for the
Advancement of Science
Convention

**December 26 to 31, 1940**